Using High-Resolution Terrestrial Lidar to Measure Stream Bank Erosion/Deposition - James McNair, Annis Water Resources Institute, Muskegon, MI, USA (co-author: K. J. Thompson)

Bank erosion is an important contributor to sediment loads and a major cause of habitat degradation in many streams. It is thought to be the dominant sediment source in most lowland catchments and tends to be particularly important in catchments that are highly urbanized, or that are primarily agricultural but with an admixture of urbanized areas or significant densities of grazing animals. Traditional methods for estimating bank erosion in the field include erosion pins and total-station surveys of channel cross sections. More recently, high-resolution terrestrial lidar has come into use. This method has considerable promise because of its high spatial resolution and ease of use, but it has practical limitations, as well. To assess the utility of this method, we used it to estimate net bank erosion at six sites on three lowland streams in coastal west Michigan, USA, between April 2015 and April 2016. Volumetric annual net erosion/deposition rates ranged from -0.40 (net erosion) to 0.14 (net deposition) m^3 sediment per m stream length. Data acquisition, data analysis, and advantages/disadvantages of the method will be discussed.

Unmanned Aerial Vehicles and Structure From Motion Techniques and Their Use in Protecting Surface Water Quality - Joby M. Prince Czarnecki, Mississippi State University, Mississippi State, MS, USA (co-authors: L. A. Hathcock, J. J. Ramirez-Avila, A. C. Linhoss, T.J. Schauwecker)

Structure from Motion (SfM) is a technique which relies on the concept of parallax to estimate 3D surfaces from 2D images. This technique has more recently been accomplished with unmanned aerial vehicles to create digital surface models. At present, SfM is gaining acceptance as a low-cost alternative to other methods which estimate surface topography (e.g., LIDAR, terrestrial laser scanning). Recent research evaluated SfM for its potential to estimate bank erosion in agricultural drainage ditches and results were favorable for the use of SfM to not only identify eroded areas, but also to quantify sediment erosion and deposition volumes. Because erosion represents a significant detriment to surface waters, as a source of both chemical (i.e., phosphorus) and physical (i.e., sediments) pollutants, significant financial investment has been made by Federal and State agencies, as well as private entities, to install best management practices on the landscape. Erosion control will be necessary for maintaining the quality of surface water resources, and identifying and monitoring erosion in critical areas will enable stakeholders to better manage water resources by addressing a key source of degradation. Accordingly, an investigation was conducted to determine the usability of low-cost, off-the-shelf unmanned aerial vehicles to perform SfM analysis, and also the suitability of this data for decision making by water resource managers. The goal of this effort was to produce a method and best practices that end users could adopt fairly easily, affordably, and quickly. This research was conducted in the Catalpa - Red Bud Creek watershed, which was recently designated as an EPA 319(h) priority watershed based on the Watershed's status as impaired under Section 303(d) of the Clean Water Act for its
sediment load, among other pollutants. The main channel of Catalpa Creek exhibits significant erosion, evidenced by channel incision and sidewall cutting; in some cases, this erosion is quite substantial and bank failure is a concern. Flights were conducted with a standard multi-rotor unmanned aircraft available, easily piloted and available for low-cost. Flights were conducted at multiple altitudes with 80% overlap of instantaneous field of view, with both north-south flight lines and east-west flight lines performed for each collection because vegetation was present in some areas of the channel (i.e., multiple viewing angles were required to see through vegetation). GPS-tagged control points were placed within the area of interest to reduce the error in the SFM digital surface model, and improved accuracy was observed. Collected data were processed with currently available, popular, image processing software packages; each had relative advantages. There were clear tradeoffs with resolution and image overlap versus processing time and storage requirements. It was also noted that higher resolution was not always desirable for images with complicated geometry; lower altitudes introduced problems with oblique views of complicated geometry. Optimal level of filtering, point cloud density, and resolution are landscape dependent, and cannot be generalized. However, acceptable digital surface models can be produced from SFM.

A Global Assessment of Surface Water Response to Drought Surrounding Dams in Border Regions - Alan Devenish, Oregon State University, Corvallis, OR, USA

This study uses remote sensing techniques to contribute novel empirical results to a growing body of research investigating links between changing environmental conditions and violent conflict. The most promising current approaches in conflict ecology avoid using climate change as a predictor of conflict, instead situating and analyzing resource depletion and land degradation as additional stress factors in regions already at risk of conflict. One such environmental condition, water scarcity, widely cited in security studies grey literature as a primary security concern under climate change, has yet to be shown to have been the definitive cause of an international conflict. Nevertheless, the Food, Energy and Water Systems (FEWS) nexus is a rapidly developing research area providing insights into international and regional dynamics in both conflict and peacebuilding contexts. With extreme weather events such as drought projected to become more common, questions around how neighboring nations share transboundary water resources are becoming more acute. This study illustrates post-drought surface water change in border regions, in particular areas surrounding dams. As powerful tools for shaping regional energy production, food security, and resilience to drought, dams are central to the FEWS nexus. Despite their benefits, the scope of dams' influence on their surroundings has made their construction and management fraught with social and environmental concerns. Problems such as mass relocation of human settlements, reallocation of water from local people to large enterprises, and disruption of habitat have drawn international attention and attempts at mitigation. Systematic study of dam impacts at the global scale is hampered by data availability, complexity, and political factors. The results of this study do not resolve those challenges, but do provide a global dataset for researchers exploring social dimensions of water use under increased scarcity. This global dataset was created in Google Earth Engine, and is accompanied by an analysis of upstream-downstream and cross-border dynamics in areas surrounding dams in border regions. The analysis draws on the 30m global surface water dataset created by the European Commission Joint Research Centre. The study explores genres of post-drought surface water response for the period 1990-2001, including cross-border comparisons. The Global Reservoir and Dam Database (GRanD) contains ~5,000 dams; of those, ~3,000 are found within a transboundary basin as defined by the Transboundary Freshwater Dispute Database (TFDD). The analysis was iterated to provide results for multiple classes of distances to borders and drought events. Trendlines within the data illustrate summaries of surface water responses to drought based on factors
such as biome, the economic and power disparity of neighboring countries, and land use spatial patterns and change.


Increased urbanisation and industrialisation has led to a degradation of water quality in recent decades due to contaminants from several sources - industrial, agricultural and anthropogenic. Traditional methods that include time consuming lab analysis from point measurements often lose out on event detection and fail to establish a complete picture of the health of the river. Recent advances in automated, multi-parametric sensor platforms, and the emergence of Cloud based storage and data analytics have enabled the ability to obtain geo-tagged, time-stamped data at high spatial and temporal resolution over large bodies of water.

Our novel approach lies in developing a scalable, low- cost real-time sensing network using mobile sensing platforms carried around pre-selected routes to obtain high frequency temporally and spatially varying water quality data. We will describe our results from such an end-to-end publicly accessible cyberphysical sensing network that we have developed for mapping stretches of the Godavari River in southern India. We will describe the results of this pilot experiment that has been in operation for several months, address its scalability and its potential impact towards pinpointing pollution sources, ensuring regulatory compliance, and benchmarking remediation measures. We will also present a comparative study for this type of novel sensing methodology across different locations in India.

Satellites as a Water Pollution Sensor: Correlating High-Resolution In-Situ Sensing and Remote Sensing Data – Sukanya Randhawa, IBM Research India, Bangalore, KA, India (co-authors: S. R. Balivada, R. B. Guruprasad, P. Hirani, S. Guha)

Developing technologies for geo-spatial monitoring of water pollution offers unique advantage in terms of studying environmental impact over very large areas and long timescales respectively. We have established a method that, utilizes geo-spatial data analytics in combination with cloud based, real-time in-situ sensing, and is capable of mapping changes in water turbidity of a water resource (any river or reservoir) due to contributing effects of pollution source/s. The method is based on first-order correlations derived from surface reflectance of different satellite bands and high resolution, geo-tagged, in-situ turbidity sensing via a moving multi-parameter sensor platform. Significant improvements in correlation (upto~73%) were obtained by using statistical methods such as moving averages for filtering out the sensing data associated noise. Standard linear regression fits were determined and compared for different satellites such as Landsat-8, Sentinel-2 and MODIS Aqua and Terra. In this manner, the remote sensed spectral band that has the highest correlation with the in-situ measurements is determined. Furthermore, the band identified is used for temporal analysis of turbidity over a longer period of time to capture any significant variations in water quality due to various factors (event or season based). Visual comparisons were also drawn via color-based heatmaps in conjunction with Google maps that facilitate visualization and identification of contributing pollutant sources. These techniques were developed based on data collected in Godavari river in south-east part of India and could be extended to any global water ecosystem.